PZ245E

P-2x5 Piezo Actuator

User Manual

Version: 1.0.1 Date: 02.03.2015

This document describes the following products:

- **P-225**
  Preloaded high-load piezo actuator
  P-225.10/.20/.40/.80: without sensor
  P-225.10V/.20V/.40V/.80V: without sensor; high-temperature range and high vacuum
  P-225.1S/.2S/.4S/.8S: with sensor
  P-225.1SV/.2SV/.4SV/.8SV: with sensor; high-temperature range and high vacuum

- **P-235**
  Preloaded high-load piezo actuator
  P-235.10/.20/.40/.80/.90: without sensor
  P-235.10V/.20V/.40V/.80V/.90V: without sensor; high-temperature range and high vacuum
  P-235.1S/.2S/.4S/.8S/.9S: with sensor
  P-235.1SV/.2SV/.4SV/.8SV/.9SV: with sensor; high-temperature range and high vacuum

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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download (p. 3) on our website.

Contents

1 About this Document 1

1.1 Goal and Target Audience of this User Manual 1
1.2 Symbols and Typographic Conventions....1
1.3 Other Applicable Documents....3
1.4 Downloading Manuals 3

2 Safety 5

2.1 Intended Use 5
2.2 General Safety Instructions 6
2.3 Organizational Measures....7

3 Product Description 9

3.1 Model Overview....9
3.2 Product View....12
3.2.1 Overview....12
3.2.2 Product Labeling....13
3.3 Scope of Delivery 14
3.4 Suitable Electronics....14
3.5 Accessories 15
3.6 Technical Features 17
3.6.1 PICA Piezo Actuators 17
3.6.2 Strain Gauge Sensors (SGS) 17

4 Unpacking 19

5 Installation 21

5.1 General Notes on Installation 21
5.2 Connecting the P-2x5 to the Protective Earth Conductor 25
5.3 Mounting the P-2x5 26
5.4 Optional: Fastening a Tip 27
5.5 Affixing the Load....27
5.6 Optional: Connecting the Protective Air 28

6 Start-Up and Operation 31

6.1 General Notes on Start-Up and Operation....31
6.2 Determining the Operating Parameters....34
6.2.1 Overview of Limiting Factors 34

6.2.2 Calculating the Effective Mass 35
6.2.3 Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator 36
6.2.4 Calculating the Forces that Occur During Dynamic Operation 37
6.2.5 Calculating the Power Requirement for Sinusoidal Operation 37
6.3 Operating the P-2x5 38
6.4 Discharging the P-2x5 38

7 Maintenance 41

7.1 General Notes on Maintenance 41
7.2 Cleaning the P-2x5 41

8 Troubleshooting 43

9 Customer Service 45

10 Technical Data 47

10.1 Specifications 47
10.1.1 Data Table 47
10.1.2 Maximum Ratings 49
10.1.3 Ambient Conditions and Classifications 50
10.2 Dimensions 50
10.2.1 P-2x5 Piezo Actuator 51
10.2.2 P-2x5 with the P-706.00 Option (Water-Resistant Case) 52
10.2.3 Ball Tip P-176.B25 52
10.2.4 Flat Tips P-176.F25 and P-176.F35 53
10.2.5 Vacuum Feedthrough for High-Voltage Piezo Actuators 54
10.2.6 Vacuum Feedthroughs for Sensors 55
10.3 Pin Assignment 56
10.3.1 Voltage Connection 56
10.3.2 Connection of the Position Sensor 56
10.3.3 Connection of the Temperature Sensor 56

11 Old Equipment Disposal 57

12 EC Declaration of Conformity 59

1 About this Document

In this Chapter

Goal and Target Audience of this User Manual 1
Symbols and Typographic Conventions 1
Other Applicable Documents 3
Downloading Manuals 3

1.1 Goal and Target Audience of this User Manual

This user manual contains the necessary information for the intended use of the P-2x5 (x stands for the different models (p. 9)).

Basic knowledge of control technology, drive technologies and suitable safety measures is assumed.

The latest versions of the user manuals are available for download (p. 3) on our website.

1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

DANGER

Imminently hazardous situation

If not avoided, the hazardous situation will result in death or serious injury.

➢ Actions to take to avoid the situation.

CAUTION

Dangerous situation

If not avoided, the dangerous situation will result in minor injury.

➢ Actions to take to avoid the situation.

NOTICE

Dangerous situation

If not avoided, the dangerous situation will result in damage to the equipment.

➢ Actions to take to avoid the situation.

INFORMATION

Information for easier handling, tricks, tips, etc.

Symbol/ Label	Meaning
1. 2.	Action consisting of several steps whose sequential order must be observed
➢	Action consisting of one or several steps whose sequential order is irrelevant
▪	List item
p. 5	Cross-reference to page 5
RS-232	Labeling of an operating element on the product (example: socket of the RS-232 interface)
	Warning signs affixed to the product that refer to detailed information in this manual.

1.3 Other Applicable Documents

The devices and software tools which are mentioned in this documentation are described in their own manuals.

The latest versions of the user manuals are available for download (p. 3) on our website.

Product	Document
E-421.00 HVPZT Piezo Amplifier module	PZ178E User Manual
E-470.20 HVPZT Piezo Amplifier	PZ178E User Manual
E-471.20 HVPZT Piezo Amplifier	PZ178E User Manual
E-472.20 HVPZT Piezo Amplifier, 2 channels	PZ178E User Manual
E-462.00 HVPZT-Piezo Amplifier	PZ210E User Manual
E-462.OE1 HVPZT Piezo Driver / Amplifier Module, 10 to 1000 V, OEM Version	PZ210E User Manual
E-464.00 HVPZT-Piezo Amplifier, 3 channels	PZ176E User Manual
E-481.00 HVPZT Piezo Amplifier / controller	PZ170E User Manual
E-482.00 PICA HVPZT Piezo Amplifier / controller	PZ236E User Manual
E-500 Modular Piezo Controller	PZ62E User Manual

1.4 Downloading Manuals

INFORMATION

If a manual is missing on our website or if there are problems in downloading:

- Contact our customer service department (p. 45).

The current versions of the manuals are found on our website. For some products (e. g. Hexapod systems and electronics that are delivered with a CD), access to the manuals is password-protected. The password is stored on the CD.

Download freely accessible manuals

1. Open the website **http://www.pi-portal.ws**.
2. Click ***Downloads***.
3. Click the corresponding category (e. g. ***P Piezo Actuators, Nanopositioning & Scanning Systems***)
4. Click the corresponding product code (e. g. ***P-225***).
5. Click ***Documents***.

   The available manuals are displayed.
6. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

Download password-protected manuals

1. Carry out steps 1 to 5 of the download process for freely accessible manuals.
2. Insert the product CD in the PC drive.
3. Switch to the ***Manuals*** directory on the CD.
4. In the ***Manuals*** directory, open the Release News (file including ***releasenews*** in the file name).
5. Find the user name and password in the ***User login for software download*** section in the Release News.
6. In the ***User login*** area on the left margin in the website, enter the user name and the password in the corresponding fields.
7. Click ***Login***.

   The available manuals are displayed.
8. Click the desired manual and save it on the hard disk of your PC or on a data storage medium.

2 Safety

In this Chapter

Intended Use 5
General Safety Instructions 6
Organizational Measures..... 7

2.1 Intended Use

The P-2x5 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil and lubricants.

In accordance with its design, the P-2x5 is intended for the following applications:

- Positioning of high loads; see "Specifications" (p. 47)
- Dynamic positioning
- Vibration damping
- Force generation

The motion takes place in one axis.

The specifications of the P-2x5 apply to mounting with a vertically oriented motion axis. Mounting with a horizontally oriented motion axis is not recommended.

The intended use of the P-2x5 is only possible in a completely mounted and connected state and only in combination with suitable drive or control electronics (p. 14) available from PI. The electronics is not included in the scope of delivery of the P-2x5.

The electronics must provide the required operating voltages. To ensure proper performance of the position control, the electronics must also be able to read out and process the signals from the position sensors.

2.2 General Safety Instructions

The P-2x5 is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the P-2x5.

- Only use the P-2x5 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the P-2x5.

Temperature changes and compressive stresses can induce charges in the P-2x5 piezo actuator. After being disconnected from the electronics, the piezo actuator can stay charged for several hours. Touching the live parts of the P-2x5 can result in serious injury or death from electric shock.

- Do **not** open the P-2x5.

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-2x5 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-2x5 can result in serious injury or death from electric shock.

- Connect the P-2x5 to a protective earth conductor (p. 25) before start-up.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e. g. in the case of modifications), reconnect the P-2x5 to the protective earth conductor before starting it up again.

Mechanical forces can damage or misalign the P-2x5.

- Avoid impacts that affect the P-2x5.
- Do **not** drop the P-2x5.
- Avoid torques, bending forces and lateral forces on the moving pusher of the P-2x5.
- Do **not** exceed the maximum permissible stress and load capacities according to the specifications (p. 47).

2.3 Organizational Measures

User manual

- Always keep this user manual available by the P-2x5.
  The latest versions of the user manuals are available for download (p. 3) on our website.
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- If you pass the P-2x5 on to other users, also turn over this user manual as well as all other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. If your user manual is incomplete and is therefore missing important information, serious or fatal injury as well as property damage can result.
- Only install and operate the P-2x5 after having read and understood this user manual.

Personnel qualification

Only authorized and qualified personnel must install, operate, maintain and clean the P-2x5.

3 Product Description

In this Chapter

Model Overview 9
Product View 12
Scope of Delivery 14
Suitable Electronics 14
Accessories 15
Technical Features 17

3.1 Model Overview

INFORMATION

Optional accessories are available for the P-2x5 piezo actuators that have to be integrated during the manufacturing of the P-2x5 (p. 15). If a P-2x5 piezo actuator is ordered with these options, it receives a customer-specific product number (beginning with "P-2x5K").

This manual also applies to all piezo actuators that have a customer-specific product number due to integrated options.

Piezo actuators without a sensor

Model	Description
P-225.10	Preloaded High-Load Piezo Actuator, 15 µm, 1000 V, 12500 N
P-225.20	Preloaded High-Load Piezo Actuator, 30 µm, 1000 V, 12500 N
P-225.40	Preloaded High-Load Piezo Actuator, 60 µm, 1000 V, 12500 N
P-225.80	Preloaded High-Load Piezo Actuator, 120 µm, 1000 V, 12500 N
P-235.10	Preloaded High-Load Piezo Actuator, 15 µm, 1000 V, 30000 N
P-235.20	Preloaded High-Load Piezo Actuator, 30 µm, 1000 V, 30000 N
P-235.40	Preloaded High-Load Piezo Actuator, 60 µm, 1000 V, 30000 N
P-235.80	Preloaded High-Load Piezo Actuator, 120 µm, 1000 V, 30000 N
P-235.90	Preloaded High-Load Piezo Actuator, 180 µm, 1000 V, 30000 N

Piezo actuators without a sensor, suitable for high-temperature range and high vacuum

Model	Description
P-225.10V	Preloaded High-Load Piezo Actuator, 15 µm, 1000 V, 12500 N, High Temperature / Vacuum
P-225.20V	Preloaded High-Load Piezo Actuator, 30 µm, 1000 V, 12500 N, High Temperature / Vacuum
P-225.40V	Preloaded High-Load Piezo Actuator, 60 µm, 1000 V, 12500 N, High Temperature / Vacuum
P-225.80V	Preloaded High-Load Piezo Actuator, 120 µm, 1000 V, 12500 N, High Temperature / Vacuum
P-235.10V	Preloaded High-Load Piezo Actuator, 15 µm, 1000 V, 30000 N, High Temperature / Vacuum
P-235.20V	Preloaded High-Load Piezo Actuator, 30 µm, 1000 V, 30000 N, High Temperature / Vacuum
P-235.40V	Preloaded High-Load Piezo Actuator, 60 µm, 1000 V, 30000 N, High Temperature / Vacuum
P-235.80V	Preloaded High-Load Piezo Actuator, 120 µm, 1000 V, 30000 N, High Temperature / Vacuum
P-235.90V	Preloaded High-Load Piezo Actuator, 180 µm, 1000 V, 30000 N, High Temperature / Vacuum

Piezo actuators with a position sensor

Model	Description
P-225.1S	Preloaded High-Load Piezo Actuator, 15 µm, 1000 V, 12500 N, SGS
P-225.2S	Preloaded High-Load Piezo Actuator, 30 µm, 1000 V, 12500 N, SGS
P-225.4S	Preloaded High-Load Piezo Actuator, 60 µm, 1000 V, 12500 N, SGS
P-225.8S	Preloaded High-Load Piezo Actuator, 120 µm, 1000 V, 12500 N, SGS
P-235.1S	Preloaded High-Load Piezo Actuator, 15 µm, 1000 V, 30000 N, SGS
P-235.2S	Preloaded High-Load Piezo Actuator, 30 µm, 1000 V, 30000 N, SGS
P-235.4S	Preloaded High-Load Piezo Actuator, 60 µm, 1000 V, 30000 N, SGS
P-235.8S	Preloaded High-Load Piezo Actuator, 120 µm, 1000 V, 30000 N, SGS
P-235.9S	Preloaded High-Load Piezo Actuator, 180 µm, 1000 V, 30000 N, SGS

Piezo actuators with a sensor, suitable for high-temperature range and high vacuum

Model	Description
P-225.1SV	Preloaded High-Load Piezo Actuator, 15 µm, 1000 V, 12500 N, SGS, High Temperature / Vacuum
P-225.2SV	Preloaded High-Load Piezo Actuator, 30 µm, 1000 V, 12500 N, SGS, High Temperature / Vacuum
P-225.4SV	Preloaded High-Load Piezo Actuator, 60 µm, 1000 V, 12500 N, SGS, High Temperature / Vacuum
P-225.8SV	Preloaded High-Load Piezo Actuator, 120 µm, 1000 V, 12500 N, SGS, High Temperature / Vacuum
P-235.1SV	Preloaded High-Load Piezo Actuator, 15 µm, 1000 V, 30000 N, SGS, High Temperature / Vacuum
P-235.2SV	Preloaded High-Load Piezo Actuator, 30 µm, 1000 V, 30000 N, SGS, High Temperature / Vacuum
P-235.4SV	Preloaded High-Load Piezo Actuator, 60 µm, 1000 V, 30000 N, SGS, High Temperature / Vacuum
P-235.8SV	Preloaded High-Load Piezo Actuator, 120 µm, 1000 V, 30000 N, SGS, High Temperature / Vacuum
P-235.9SV	Preloaded High-Load Piezo Actuator, 180 µm, 1000 V, 30000 N, SGS, High Temperature / Vacuum

3.2 Product View

3.2.1 Overview

The figure serves as an example and can differ from your model.

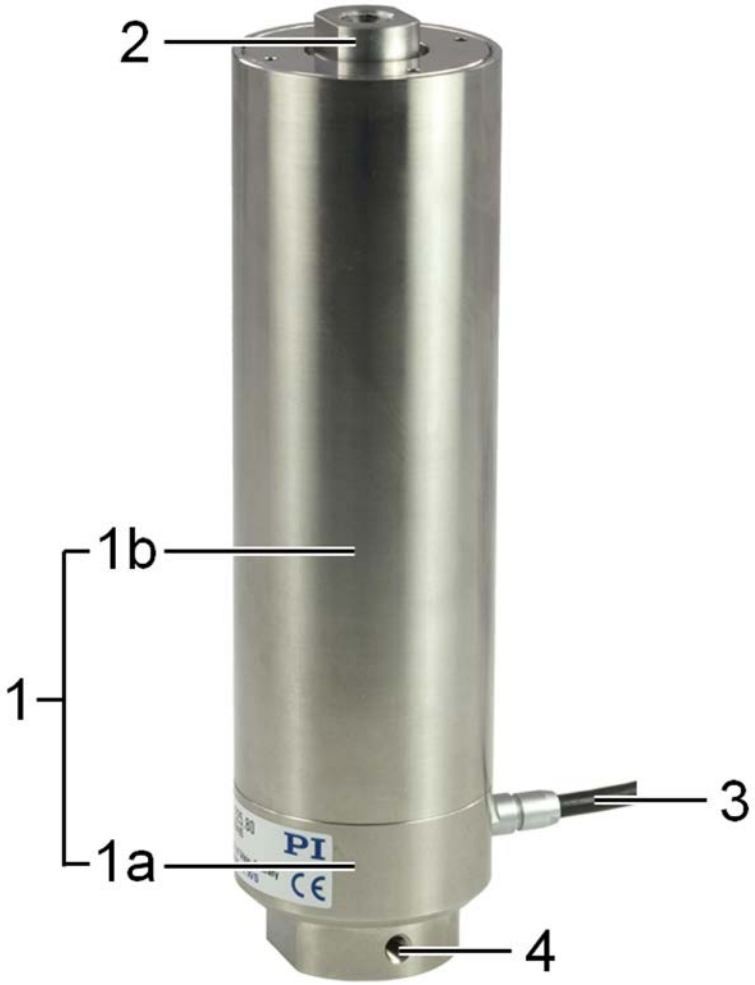


Figure 1: Example of product view

1 Case, consisting of:
1a: Base with wrench flat
1b: Case tube
Not shown here: Optional inlets and outlets for protective air, optional water protection

2 Moving pusher with wrench flat and M8 internal thread

3 Cable exit for piezo voltage
Not shown here: Cable exits for sensors

4 Protective earth connection

3.2.2 Product Labeling

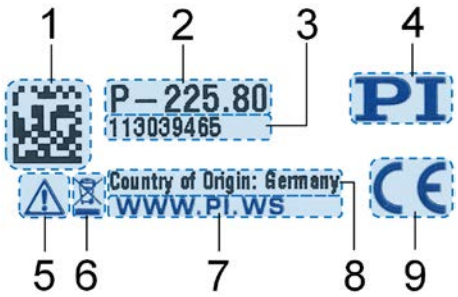


Figure 2: P-2x5: Type plate (example view)

1 Data matrix code (contains the serial number)
2 Product name
3 Serial number
4 Manufacturer's logo
5 Warning sign "Observe manual!"
6 Disposal of used devices
7 Manufacturer's address (website)
8 Country of origin
9 CE conformity mark

Figure 3: P-2x5: Warning sign "DANGER" on voltage connection (with attached shorting plug)

Warning sign "DANGER": Notice of risk of electric shock (p. 6)

3.3 Scope of Delivery

Item ID	Items
P-2x5	Piezo actuator according to order (p. 9)
000036450	M4 screw set for protective earth, consisting of: ▪ 1 M4x8 flat-head screw with cross recess, ISO 7045 ▪ 2 safety washers ▪ 2 flat washers
P-202.01	Shorting plug for high-voltage piezo actuators, with internal discharge resistor of 10 kΩ
PZ246EK	Short instructions for high-voltage piezo actuators

3.4 Suitable Electronics

To operate a P-2x5, you need electronics. The device is selected depending on the type of application. The table below lists the suitable products.

Product code	Description
E-421.00	HVPZT Piezo Amplifier Module, 550 W, 1100 V, Integrated P / S
E-470.20	HVPZT Piezo Amplifier, 550 W, 1100 V, Bench-Top
E-471.20	HVPZT Piezo Amplifier, Controller & Interface / Display Upgrade possible, 550 W, 1100 V, Bench-Top, 19"
E-472.20	HVPZT Piezo Amplifier, 2 Channels, 550 W, 1100 V, Bench-Top, 19"
E-462.00	HVPZT-Piezo Amplifier, 10 bis 1000 V, Bench-Top Device
E-462.OE1	HVPZT Piezo Driver / Amplifier Module, 10 to 1000 V, OEM Version
E-464.00	HVPZT Piezo Amplifier, 3 Channels, 1100 V, Bench-Top
E-481.00	HVPZT Piezo Amplifier / Controller, Energy Recovery, 1100 V, 2000 W, 19''
E-482.00	PICA High-Power Piezo Driver / Controller with Energy Recovery, 1050 V, 6 A, 19''

Product code	Description
E-500	Modular piezo controller (configuration example) High-voltage piezo amplifier for PICA HVPZT, 3 channels, with PC interface and display, consisting of: 1 × E-500.00 19"-Chassis for Modular Piezo Controller System, 1 to 3 Channels 3 × E-508.00 HVPZT Piezo Amplifier Module, +3 to +1100 V, 1 Channel 1 × E-517.i3 Interface / Display Module, 24 Bit D/A, TCP/IP, USB, RS-232, IEEE488, 3 Channels Optionally as high-voltage amplifier / servo controller additionally with: 1 × E-509.S3 Sensor / Piezo Servo-Control Module, SGS Sensors, 3 Channels

- To order, contact our customer service department (p. 45).
- Before selecting electronics, calculate the power requirements of the application (p. 37).

3.5 Accessories

Options with a gray background have to be ordered together with the P-2x5 piezo actuator for manufacturing reasons. Piezo actuators that are equipped with these options have a customer-specific product number (beginning with "P-2x5K").

Order Number	Description
P-177.50	PT1000 temperature sensor and protective air connection for PICA high-voltage piezo actuators (with E-481 and E-482 controllers)
P-706.00	Water-resistant case for P-225, P-235
P-176.B25	Ball tip for P-225 and P-235
P-176.F25	Flat tip for P-225
P-176.F35	Flat tip for P-235
P-203.VA	Vacuum feedthrough for high-voltage piezo actuators, up to 10^{-6} hPa, 100 °C, consisting of: ▪ Vacuum feedthrough LEMO SJG.0B.701.CJA.1173 ▪ Air-side cable with 2 LEMO connectors, 2 m

Order Number	Description
P-892.VA	Vacuum feedthrough strain gauge sensor, up to 10^{-6} hPa, 100 °C, consisting of: ▪ Vacuum feedthrough LEMO SWH.0S.304.CLLSV ▪ Air-side cable with 2 LEMO connectors, 2 m
P-899.VA	Vacuum feedthrough temperature sensor, up to 10^{-6} hPa, 100 °C, consisting of: ▪ Vacuum feedthrough LEMO SWH.0S.303.CLLSV ▪ Air-side cable with 2 LEMO connectors, 2 m

Order Number	Description
P-203.01	Extension Cable for PICA HVPZT Actuators, 1 m
P-203.02	Extension Cable for PICA HVPZT Actuators, 2 m
P-203.03	Extension Cable for PICA HVPZT Actuators, 3 m
P-203.05	Extension Cable for PICA HVPZT Actuators, 5 m
P-203.10	Extension Cable for PICA HVPZT Actuators, 10 m
P-203.15	Extension Cable for PICA HVPZT Actuators, 15 m
Connector (m): FGG.0B.701.CJA.1173; connector (f): PHG.0B.701.CJL.1173	

Order Number	Description
P-892.01	Extension Cable for Strain Gauge Sensors, LEMO Connector(s), 1 m
P-892.02	Extension Cable for Strain Gauge Sensors, LEMO Connector(s), 2 m
P-892.03	Extension Cable for Strain Gauge Sensors, LEMO Connector(s), 3 m
P-892.05	Extension Cable for Strain Gauge Sensors, LEMO Connector(s), 5 m
P-892.10	Extension Cable for Strain Gauge Sensors, LEMO Connector(s), 10 m
P-892.15	Extension Cable for Strain Gauge Sensors, LEMO Connector(s), 15 m
Connector (m): FFA.0S.304.CLAC32; connector (f): PCA.0S.304.CLLC32	

Order Number	Description
P-899.01	Extension cable for temperature sensor, LEMO connectors, 1 m
P-899.02	Extension cable for temperature sensor, LEMO connectors, 2 m
P-899.03	Extension cable for temperature sensor, LEMO connectors, 3 m
P-899.05	Extension cable for temperature sensor, LEMO connectors, 5 m
P-899.07	Extension cable for temperature sensor, LEMO connectors, 7 m
P-899.10	Extension cable for temperature sensor, LEMO connectors, 10 m
P-899.15	Extension cable for temperature sensor, LEMO connectors, 15 m
Connector (m): FFA.0S.303.CLAC32; connector (f): PCA.0S.303.CLLC32	

➢ To order, contact our customer service department (p. 45).

3.6 Technical Features

3.6.1 PICA Piezo Actuators

P-2x5 are preloaded, high-load piezo actuators for static and dynamic applications. They provide a sub-millisecond response and sub-nanometer resolution.

The piezo actuators have a friction-free, preloaded PICA Power piezo ceramic that is integrated in a stainless-steel case. The high load capacity and internal preload makes them ideal for applications such as precision manufacturing and active vibration damping.

3.6.2 Strain Gauge Sensors (SGS)

Strain gauge sensors derive the position information from their expansion. A strain gauge sensor consists of an electrically conductive film, the resistance of which changes with the strain. Strain gauge sensors are attached to the actuator and measure its displacement. The sensors are equipped with a full-bridge circuit that is insensitive to thermal drift, and assure optimum position stability in the nanometer range.

4 Unpacking

NOTICE

Destruction of the piezo actuator by discharging too quickly!

If the P-2x5 is not connected to the electronics, the lines on the voltage connection must be short-circuited with a **discharge resistor of 10 kΩ** in order to prevent the piezo actuator from charging when temperature changes and compressive stresses occur. Unsuitable short-circuiting leads to an abrupt contraction of the piezo actuator due to excessively fast discharging. Abrupt contraction can destroy the piezo actuator.

- ➢ Only remove the supplied shorting plug from the voltage connection of the piezo actuator when this is necessary for installation or operation.
- ➢ Keep the shorting plug near the piezo actuator after removing it.
- ➢ Only use the supplied shorting plug to short-circuit the lines at the voltage connection of the piezo actuator.

Figure 4: Voltage connection of the P-2x5 with attached shorting plug

1 Voltage connection of the P-2x5

2 P-202.01 shorting plug, in the scope of delivery

INFORMATION

When handling the vacuum version of the piezo actuator, appropriate cleanliness must be ensured. At PI, all parts are cleaned before assembly. During assembly and calibration, powder-free gloves are worn. Afterwards, the piezo actuator is cleaned once again by wiping and shrink-wrapped twice in vacuum-compatible film.

- Only touch the piezo actuator with powder-free gloves.
- If necessary, wipe the piezo actuator clean after unpacking.

1. Unpack the P-2x5 with care.
2. Compare the contents against the items covered by the contract and against the packing list.
3. Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.

5 Installation

In this Chapter

General Notes on Installation 21
Connecting the P-2x5 to the Protective Earth Conductor 25
Mounting the P-2x5 26
Optional: Fastening a Tip 27
Affixing the Load 27
Optional: Connecting the Protective Air 28

5.1 General Notes on Installation

NOTICE

Destruction of the piezo actuator by discharging too quickly!

If the P-2x5 is not connected to the electronics, the lines on the voltage connection must be short-circuited with a **discharge resistor of 10 kΩ** in order to prevent the piezo actuator from charging when temperature changes and compressive stresses occur. Unsuitable short-circuiting leads to an abrupt contraction of the piezo actuator due to excessively fast discharging. Abrupt contraction can destroy the piezo actuator.

- ➢ Only remove the supplied shorting plug from the voltage connection of the piezo actuator when this is necessary for installation or operation.
- ➢ Keep the shorting plug near the piezo actuator after removing it.
- ➢ Only use the supplied shorting plug to short-circuit the lines at the voltage connection of the piezo actuator.

NOTICE

Destruction of the piezo actuator by loads that are too high!

Loads that are too high can destroy the P-2x5.

- ➢ Do **not** exceed the maximum tensile/compressive stress capacity according to the specifications (p. 47).

NOTICE

Destruction of the piezo actuator by mechanical overload!

Torques, bending forces, shearing forces and lateral forces can destroy the piezo actuator.

- Avoid bending forces and lateral forces on the pusher of the P-2x5.
- Do **not** exceed the maximum torque and the maximum shearing load on the pusher according to the specifications (p. 47).
- Avoid torques on the base when the pusher is tightly clamped.
- Make sure that the center of load of the moving system is on the motion axis of the piezo actuator.
- Avoid an uneven load distribution by using suitable structures or guide elements (e.g. ball tips or flexure guides).
- Observe the information on parallelism in the "Dimensions" section (p. 47).
- Do **not** screw the piezo actuator tight on both ends.

Piezo actuators may only be loaded axially. The following figures are to help you avoid mounting errors.

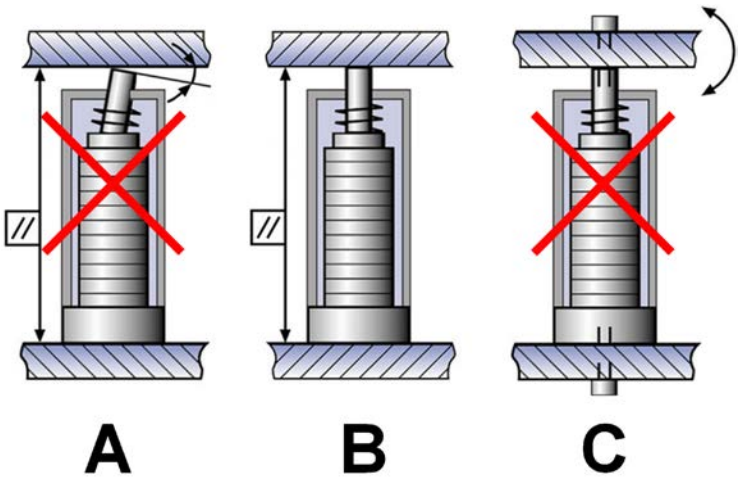


Figure 5: Not tightly screwed at both ends and no angles

A: Incorrect: Angle error on the pusher

B: Correct: Axial loading of the actuator

C: Incorrect: Both ends of the actuator screwed in tight

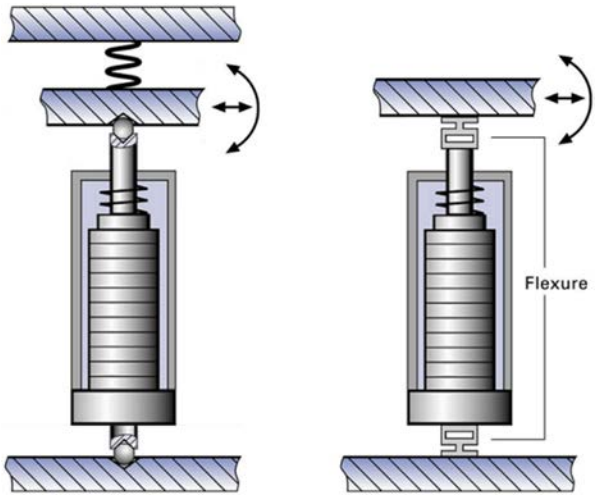


Figure 6: Ball tips or flexure joints for decoupling lateral forces and bending forces

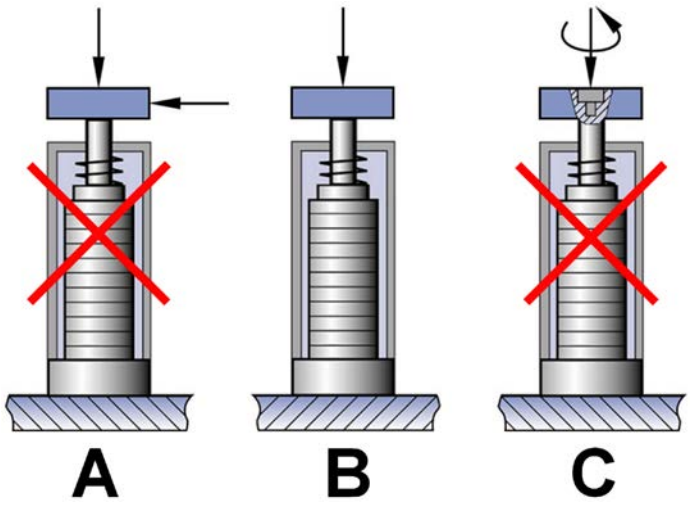


Figure 7: No lateral forces or torques

A: Incorrect: Shearing force from lateral force

B: Correct: Axial loading of the actuator

C: Incorrect: Torsion from torque

NOTICE

Damage from unsuitable cables!

Unsuitable cables can damage the piezo actuator and the electronics.

- ➢ Only use cables provided by PI for connecting the P-2x5 to the electronics.

NOTICE

Heating up of the P-2x5 during operation!

The heat produced during operation of the P-2x5 can affect your application.

- ➢ Install the P-2x5 so that your application is not affected by the dissipating heat.

INFORMATION

Extended cables can affect the performance of the P-2x5.

- ➢ Only use extension cables from PI (p. 15).

INFORMATION

When handling the vacuum version of the piezo actuator, appropriate cleanliness must be ensured.

- ➢ Only touch the piezo actuator with powder-free gloves.
- ➢ If necessary, wipe the piezo actuator clean.

INFORMATION

The outwards motion of the pusher corresponds to the positive direction of motion and is proportional to the applied operating voltage.

5.2 Connecting the P-2x5 to the Protective Earth Conductor

INFORMATION

➢ Observe the applicable standards for mounting the protective earth conductor.

The P-2x5 has an M4 threaded hole for connecting the protective earth conductor. This hole is located on the base of the piezo actuator and is marked in the dimensional drawing with ⏚, the symbol for the protective earth conductor; see "Dimensions" (p. 50).

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 21).
- ✓ The supplied shorting plug is attached to the voltage connection of the P-2x5, see "Unpacking" (p. 19).
- ✓ The P-2x5 is **not** connected to the electronics.

Tools and accessories

- Suitable protective earth conductor: Cross-sectional area of the cable ≥0.75 mm^2 and protective earth conductor resistance <0.1 Ω at 25 A
- Supplied M4 protective earth screw set (p. 14) for connecting the protective earth conductor
- Suitable screwdriver

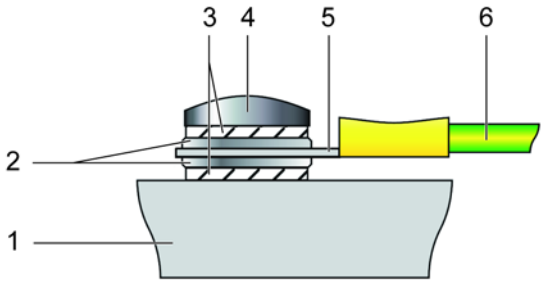


Figure 8: Mounting of the protective earth conductor (profile view)

1 Base of the P-2x5
2 Flat washer
3 Safety washer
4 Screw
5 Cable lug
6 Protective earth conductor

Connecting the P-2x5 to the protective earth conductor

1. If necessary, fasten a suitable cable lug to the protective earth conductor.
2. Fasten the cable lug of the protective earth conductor using the M4 screw on the protective earth connection of the P-2x5 as shown in the profile view.
3. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.
4. Make sure that the contact resistance at all connection points relevant for mounting the protective earth conductor is <0.1 Ω at 25 A.

5.3 Mounting the P-2x5

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 21).
- ✓ The supplied shorting plug is attached to the voltage connection of the P-2x5, see "Unpacking" (p. 19), or the P-2x5 is connected to the **switched-off** electronics from PI.

Tools and accessories

- M8 screw of suitable length; see "Dimensions" (p. 50)
- Suitable tools for fastening the screw
- Open-end wrench AF 27

Mounting the P-2x5

1. Use an AF 27 open-end wrench to hold the base of the P-2x5 by the wrench flats.
2. Mount the P-2x5 on a suitable surface with an M8 screw. For this purpose, use the M8 mounting hole on the bottom side of the base; see "Dimensions" (p. 50).
3. Remove the open-end wrench from the base.

5.4 Optional: Fastening a Tip

INFORMATION

The optionally available tips (p. 15) make it possible to realize different mechanical connections to a load.

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 21).
- ✓ The supplied shorting plug is attached to the voltage connection of the P-2x5, see "Unpacking" (p. 19), or the P-2x5 is connected to the **switched-off** electronics from PI.

Tools and accessories

- Optionally available tip (p. 15)
- Open-end wrench for holding the pusher:
  - P-225: AF 13
  - P-235: AF 17

Fastening a tip

1. Use a suitable open-end wrench to hold the wrench flats of the pusher.
2. Manually screw the tip into the mounting hole in the pusher of the P-2x5.
3. Remove the open-end wrench from the pusher.

5.5 Affixing the Load

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 21).
- ✓ The supplied shorting plug is attached to the voltage connection of the P-2x5, see "Unpacking" (p. 19), or the P-2x5 is connected to the **switched-off** electronics from PI.

Tools and accessories

- M8 screw of suitable length; see "Dimensions" (p. 50)
- Suitable screwdriver

- Open-end wrench for holding the pusher:
  - P-225: AF 13
  - P-235: AF 17

Affixing the load

1. Use a suitable open-end wrench to hold the wrench flats of the pusher.
2. Fasten the load to the mounting hole in the pusher with an M8 screw; see "Dimensions" (p. 50).
3. Remove the open-end wrench from the pusher.

5.6 Optional: Connecting the Protective Air

NOTICE

Destruction of the piezo actuator by cooling too quickly!

If the cooling is too fast, the resulting thermomechanical load can destroy the piezo actuator.

➢ Only connect the protective air to the piezo actuator when the piezo actuator has cooled down to room temperature.

INFORMATION

The piezo actuator can be cooled with protective air when the P-2x5 has been ordered with the option "PT1000 temperature sensor and protective air connection for PICA high-voltage piezo actuators" (P-177.50) (p. 15).

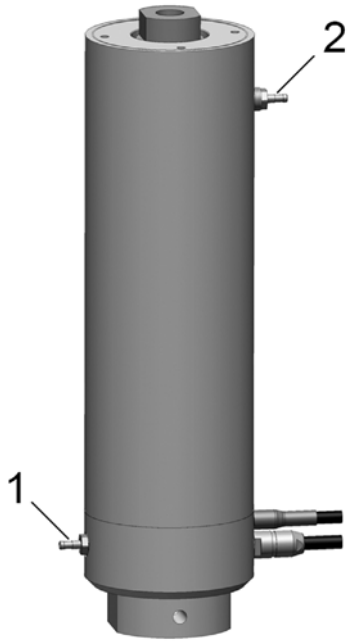


Figure 9: P-2x5: Protective air connection with P-177.50 option

1 Inlet for protective air, M3-PK-2 plug nipple
2 Outlet for protective air, M3-PK-2 plug nipple

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 21).
- ✓ The supplied shorting plug is attached to the voltage connection of the P-2x5, see "Unpacking" (p. 19), or the P-2x5 is connected to the **switched-off** electronics from PI.

Tools and accessories

- Hoses for feeding and discharging the protective air, suitable for M3-PK-2 plug nipple
- Suitable protective air:
  - Compressed air according to ISO 8573.1, quality class 4, that is passed through a dryer and a microfilter with 99.9999% efficiency
  - The maximum air pressure in the piezo actuator must not be more than 0.5 bar (7.3 psi).

Connecting the protective air

1. Make sure that the piezo actuator has cooled down to room temperature.
2. Connect the protective air:
   - Attach the hose for feeding the protective air to the corresponding plug nipple on the P-2x5 (see above figure).
   - Attach the hose for discharging the protective air to the corresponding plug nipple on the P-2x5 (see above figure).

6 Start-Up and Operation

In this Chapter

General Notes on Start-Up and Operation 31
Determining the Operating Parameters 34
Operating the P-2x5 38
Discharging the P-2x5 38

6.1 General Notes on Start-Up and Operation

DANGER

Risk of electric shock if the protective earth conductor is not connected!

If a protective earth conductor is not or not properly connected, dangerous touch voltages can occur on the P-2x5 in the case of malfunction or failure of the system. If touch voltages exist, touching the P-2x5 can result in serious injury or death from electric shock.

- Connect the P-2x5 to a protective earth conductor (p. 25) before start-up.
- Do **not** remove the protective earth conductor during operation.
- If the protective earth conductor has to be removed temporarily (e. g. in the case of modifications), reconnect the P-2x5 to the protective earth conductor before starting it up again.

CAUTION

Burning from hot surface!

The surface of the P-2x5 can become hot during operation. Touching the P-2x5 can cause slight injuries from burning.

- Cool the P-2x5 e.g. with protective air (p. 28) so that the temperature of its surface does **not** exceed 65 °C.
- If sufficient cooling is not possible: Make sure that the hot P-2x5 **cannot** be touched.
- When sufficient cooling and protection against contact are not possible: Mark the danger zone according to the legal regulations.

NOTICE

Destruction of the piezo actuator by electric flashovers!

The use of the P-2x5 in environments that increase the electrical conductivity can lead to the destruction of the piezo actuator by electric flashovers. Electric flashovers can be caused by moisture, high humidity, liquids and conductive materials such as metal dust. In addition, electric flashovers can also occur in certain air pressure ranges due to the increased conductivity of the air.

- ➢ Avoid operating the P-2x5 in environments that can increase the electric conductivity.
- ➢ Only operate the P-2x5 within the permissible ambient conditions and classifications (p. 50).
- ➢ For operation in vacuum below 0.1 hPa:
  Do **not** operate the P-2x5 during evacuation.

NOTICE

Destruction of the piezo actuator by dynamic forces!

During dynamic operation, dynamic forces can occur that cancel the preload of the piezo actuator. Operation without a preload can destroy the actuator.

- ➢ Do **not** exceed the maximum tensile/compressive stress capacity according to the specifications (p. 47).
- ➢ Observe the notes in "Determining the Operating Parameters" (p. 34).

NOTICE

Destruction of the piezo actuator by operating frequencies that are too high!

An operating frequency that is too high can destroy the piezo actuator.

- ➢ Select the operating frequency so that the following conditions are met:
  - The operating frequency is maximally one third of the resonant frequency (resonant frequency of the unloaded piezo actuator see "Data Table" (p. 47), resonant frequency of the loaded piezo actuator see "Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 36)).
  - The dynamic forces that occur during operation do **not** exceed the maximum tensile/compressive stress capacity of the piezo actuator (see "Calculating Forces that Occur During Dynamic Operation" (p. 37)).

NOTICE

Reduced lifetime of the piezo actuator due to permanently high voltage!

The permanent application of a high static voltage to piezo actuators leads to a considerable reduction in the lifetime of the piezo ceramics of the actuator.

- When the P-2x5 is not used but the electronics remain switched on to ensure temperature stability, discharge the P-2x5 (p. 38).
- If possible: Limit the maximum operating voltage to 750 V during continuous operation.

NOTICE

Operating voltages that are too high or incorrectly connected!

Operating voltages that are too high or incorrectly connected can cause damage to the P-2x5.

- Only operate the P-2x5 with controllers/drivers and original accessories from PI.
- Do **not** exceed the operating voltage range (p. 49) for which the P-2x5 is specified.
- Only operate the P-2x5 when the operating voltage is properly connected; see "Pin Assignment" (p. 56).

NOTICE

Destruction of the piezo actuator by overheating!

Overheating can destroy the piezo actuator.

- Cool the piezo actuator with e.g. protective air (p. 28).
- Monitor the temperature of the piezo actuator with a temperature sensor (p. 15).
- Adjust the operating voltage, operating frequency and/or operating time so that the maximum operating temperature of the piezo actuator is not exceeded, see "Ambient Conditions and Classifications" (p. 50), "Maximum Ratings" (p. 49) and "Determining the Operating Parameters" (p. 34).

NOTICE

Uncontrolled oscillation!

Oscillations can cause irreparable damage to the piezo actuator. Oscillations are indicated by a humming and can result from the following causes:

- A change in the load and/or dynamics requires the servo-control parameters to be adjusted.
- The piezo actuator is operated near its resonant frequency.

If you notice oscillations:

➢ In closed-loop operation, immediately switch off the servo mode.

➢ In open-loop operation, immediately stop the piezo actuator.

INFORMATION

The outwards motion of the pusher corresponds to the positive direction of motion and is proportional to the applied operating voltage.

6.2 Determining the Operating Parameters

6.2.1 Overview of Limiting Factors

Limiting factors for the operation of the piezo actuator:

- Resonant frequency:

  The resonant frequency must **not** exceed one third of the resonant frequency of the loaded piezo actuator. See "Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 36).

- Maximum tensile/compressive stress capacity (p. 47):

  The mass of the load to be moved and the operating frequency of the piezo actuator must be selected so that the dynamic forces that occur during operation do not exceed the maximum tensile/compressive stress capacity of the piezo actuator. See "Calculating the Forces that Occur During Dynamic Operation" (p. 37).

- Maximum permissible operating temperature of the piezo actuator (p. 50):

  The greater the operating frequency, the operating voltage (peak-to-peak), and the capacitance of the piezo actuator, the greater the thermal power generated in the piezo actuator. The operating frequency, operating voltage and operating time must be selected so that the maximum permissible operating temperature of the piezo actuator is **not** exceeded. For the maximum permissible operating frequency without cooling, see column B of the table in "Maximum Ratings" (p. 49).

  When cooling measures (p. 28) are used, the limit values for the operating frequency, operating voltage and operating time increase. The use of a temperature sensor (p. 15) can prevent the piezo actuator from overheating.

- Peak and average output current of the used electronics (p. 14):

  The used electronics must be selected so that it can supply the required currents. See "Calculating the Power Requirement for Sinusoidal Operation" (p. 37).

6.2.2 Calculating the Effective Mass

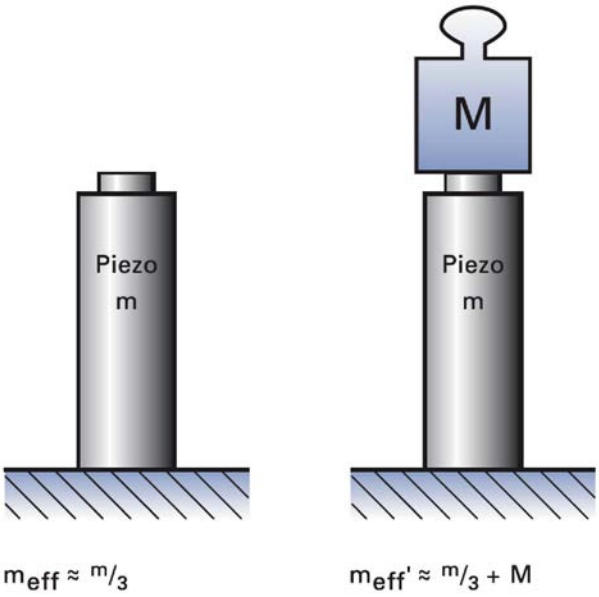


Figure 10: Effective mass of an unloaded piezo actuator (left) and a piezo actuator loaded with an additional mass M (right). Each piezo actuator is permanently mounted at one end.

1. Find the mass m of your piezo actuator in the data table (p. 47).
2. Determine the additional mass M.
3. Calculate the effective mass m_{eff} of the unloaded piezo actuator and m_{eff}' of the loaded piezo actuator with the formulas in the above figure.

6.2.3 Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator

INFORMATION

In the following calculation, the maximum permissible operating temperature of the piezo actuator is **not** taken into account. During operation without cooling, the maximum operating temperature may already be exceeded when the operating frequency is still below the limit value calculated in the following.

➢ For the maximum permissible operating frequency without cooling, see column B of the table in "Maximum Ratings" (p. 49).

1. Calculate the resonant frequency of the loaded piezo actuator with the following formula:

$$f_0' = f_0 \sqrt{\frac{m_{eff}}{m_{eff}'}}$$

f_0' = Resonant frequency of the loaded piezo actuator [Hz]

f_0 = Resonant frequency of the unloaded piezo actuator [Hz]; see "Data Table" (p. 47).

m_{eff} = Effective mass; approx. 1/3 of the mass of the piezo actuator [kg]

m_{eff}' = Effective mass m_{eff} + additional mass M [kg]

See also "Calculating the Effective Mass" (p. 35).

2. Calculate the maximum operating frequency of the loaded piezo actuator with the following formula:

$f_{max} = f_0'/3$

f_{max} = Maximum operating frequency of the loaded piezo actuator [Hz]

f_0' = Resonant frequency of the loaded piezo actuator [Hz]

6.2.4 Calculating the Forces that Occur During Dynamic Operation

- Calculate the dynamic forces that act on the piezo actuator during sinusoidal operation with the frequency f, with the following formula:

$$F_{dyn} \approx \pm 4\pi^2 \cdot m_{eff}' \left(\frac{\Delta L}{2}\right) f^2$$

F_{dyn} = Dynamic force [N]

m_{eff}' = Effective mass m_{eff} (approx. 1/3 of the mass of the piezo actuator) + additional mass M [kg], see also "Calculating the Effective Mass" (p. 35)

ΔL = Displacement in the application (peak-to-peak) [m]

f = Frequency [Hz]

Example: The dynamic forces at 1000 Hz, 2 µm displacement (peak-to-peak) and 1 kg effective mass are approximately ±40 N.

6.2.5 Calculating the Power Requirement for Sinusoidal Operation

- Calculate the average current requirement for sinusoidal operation with the following formula:

$$I_a \approx f \cdot C \cdot U_{p\text{-}p}$$

- Calculate the peak current requirement for sinusoidal operation with the following formula:

$$I_{max} \approx f \cdot \pi \cdot C \cdot U_{p\text{-}p}$$

Variable	Description	Notes
I_a	Required average current of the amplifier (source / sink) [A]	It is essential for the power supply to supply enough current.
I_{max}	Required peak current of the amplifier (source / sink) [A]	
f	Operating frequency [Hz]	Details on the operating frequency see "Overview of Limiting Factors" (p. 34).

Variable	Description	Notes
C	Capacitance of the piezo actuator [F (= As/V)]	See "Data Table" (p. 47) for the small-signal capacitance of the piezo actuator. For large-signal conditions, a safety factor of 70 % should be added to the small-signal capacitance.
U_{p-p}	Operating voltage (peak-to-peak) [V]	

6.3 Operating the P-2x5

Prerequisite

- ✓ You have read and understood the General Notes on Start-Up and Operation (p. 31).
- ✓ You have determined the operating parameters for your application (p. 34).
- ✓ You have correctly installed the P-2x5 (p. 21).
- ✓ You have provided suitable electronics that can supply the required currents (p. 37).
- ✓ You have read and understood the user manual of the used electronics.

Operating the P-2x5

- ➢ Follow the instructions in the manual of the used electronics for connecting, starting up and operating the P-2x5 (p. 14).

6.4 Discharging the P-2x5

The P-2x5 must be discharged in the following cases:

- When the P-2x5 is not used but the electronics remain switched on to ensure temperature stability
- Before demounting (e.g. before cleaning and transporting the P-2x5) and for modifications

Prerequisite

- ✓ You have read and understood the General Notes on Installation (p. 21).

Tools and accessories

If the P-2x5 is not connected to the electronics:

- Supplied shorting plug (p. 14)
- Alternative: Electronics from PI

Discharging a P-2x5 connected to the electronics

In closed-loop operation:

1. Switch off the servo mode on the electronics.
2. Set the piezo voltage to 0 V on the electronics.

In open-loop operation:

➢ Set the piezo voltage to 0 V on the electronics.

Discharging a P-2x5 that is not connected to the electronics

➢ Connect the voltage connection of the piezo actuator with the shorting plug (see "Unpacking" (p. 19)).

➢ Alternative: Connect the voltage connection of the piezo actuator to the switched-off electronics from PI.

7 Maintenance

In this Chapter

General Notes on Maintenance 41
Cleaning the P-2x5 41

7.1 General Notes on Maintenance

The P-2x5 is maintenance-free.

7.2 Cleaning the P-2x5

NOTICE

Destruction of the piezo actuator by electric flashovers!

The intrusion of fluids into the case of the piezo actuator can lead to the destruction of the piezo actuator by electric flashovers.

Before cleaning the P-2x5:

- ➢ Discharge the P-2x5 (p. 38).
- ➢ Disconnect the voltage connection of the P-2x5 from the electronics.
- ➢ Connect the voltage connection of the P-2x5 with the supplied shorting plug (p. 19).

Prerequisites

- ✓ You have discharged the piezo actuators of the P-2x5 (p. 38).
- ✓ You have disconnected the P-2x5 from the electronics.
- ✓ The supplied shorting plug is attached to the voltage connection of the P-2x5, see "Unpacking" (p. 19).

Cleaning the P-2x5

- Do **not** do any ultrasonic cleaning.

Only when the piezo actuator is **not** used in vacuum:

- When necessary, clean the surfaces of the P-2x5 with a cloth that is lightly dampened with a mild cleanser or disinfectant (e.g. alcohol or isopropanol).

When the piezo actuator is used in a vacuum:

- Only touch the piezo actuator with powder-free gloves.
- If necessary, wipe the piezo actuator clean.

8 Troubleshooting

Problem	Possible Causes	Solution
No or limited motion	The cable is not connected correctly	➢ Check the cable connections.
	Excessive load	➢ Do **not** exceed the permissible compressive/tensile stress capacity according to the specifications (p. 47).
	The E-481 or E-482 electronics from PI has deactivated the voltage output due to overheating of the piezo actuator	If the piezo actuator is equipped with the option "PT1000 temperature sensor and protective air connection for PICA high-voltage piezo actuators" (p. 15), the E-481 and E-482 electronics evaluate the signal of the temperature sensor. 1. Switch off the electronics. 2. Wait a few minutes until the piezo actuator has sufficiently cooled down. 3. Switch the electronics on again. Preventive measures: ➢ Reduce the operating voltage, operating frequency and/or operating time. ➢ Cool the piezo actuator.
	Zero shift of the position sensor for the following reasons: ▪ Load in direction of motion ▪ Ambient/operating temperature of the piezo actuator is far above or below the calibration temperature (21 °C to 24 °C)	➢ Perform a zero-point adjustment of the sensor (see manual of the electronics used).
	Piezo actuator is depolarized due to overheating	➢ Contact our customer service department (p. 45).

Problem	Possible Causes	Solution
Reduced accuracy	P-2x5 or controller has been replaced	➢ Perform a recalibration of the axis displacement (see controller manual) or contact our customer service department (p. 45).
	Axes were mixed up during connection	With calibrated systems: ➢ Observe the assignment of the axes when connecting several piezo actuators to a multi-channel controller. This assignment is indicated by labels on the devices.
The piezo actuator starts oscillating or positions inaccurately	Servo-control parameters incorrectly set because e. g. the load was changed	1. Immediately switch off the servo mode of the corresponding axes. 2. Check the settings of the servo-control parameters on the controller. 3. Adjust the servo-control parameters on the controller according to the load change.
	Operation with frequency that is too high	➢ Operate the piezo actuator with maximally one third of the resonant frequency (resonant frequency of the unloaded piezo actuator see "Data Table" (p. 47), resonant frequency of the loaded piezo actuator see "Calculating the Maximum Operating Frequency of the Loaded Piezo Actuator" (p. 36)).

If the problem that occurred with your system is not listed in the table above or cannot be solved as described, contact our customer service department (p. 45).

9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (info@pi.ws).

If you have questions concerning your system, have the following information ready:

- Product codes and serial numbers of all products in the system
- Firmware version of the controller (if present)
- Version of the driver or the software (if present)
- Operating system on the PC (if present)

The latest versions of the user manuals are available for download (p. 3) on our website.

10 Technical Data

In this Chapter

Specifications 47
Dimensions 50
Pin Assignment 56

10.1 Specifications

10.1.1 Data Table

	P-225.10	P-225.20	P-225.40	P-225.80	Unit	Tolerance
Operating voltage	0 to 1000	0 to 1000	0 to 1000	0 to 1000	V	
Motion and positioning						
Closed-loop travel*	15	30	60	120	µm	
Closed-loop resolution*	0.3	0.6	1.2	2.4	nm	typ.
Open-loop resolution**	0.15	0.3	0.6	1.2	nm	typ.
Linearity error	0.2	0.2	0.2	0.2	%	typ.
Mechanical properties						
Static large-signal stiffness in the direction of motion***	480	330	200	110	N/µm	±20 %
Unloaded resonant frequency	14	10	7	4	kHz	±20 %
Push / pull force capacity in motion direction	12500 / 2000	12500 / 2000	12500 / 2000	12500 / 2000	N	max.
Shear load	255	152	84	73	N	max.
Torque on tip	1.5	1.5	1.5	1.5	Nm	max.
Drive properties						
Electrical capacitance	320	630	1300	2600	nF	±20 %
Dynamic operating current coefficient	33	33	33	33	µA / (Hz × µm)	±20 %
Miscellaneous						
Mass (with cable)	410	470	610	900	g	±5 %

Piezo ceramic: PICA Power

Temperature range: -40 to 80 °C

The operating voltage should not exceed 750 V in continuous operation.

* Requires integrated strain gauge sensor. These versions are shipped with a performance report.

** Measured interferometrically. The position resolution of piezo actuators is not limited by stiction or friction.

*** Dynamic small-signal stiffness is approx. 50 % higher.

	P-235.10	P-235.20	P-235.40	P-235.80	P-235.90	Unit	Tolerance
Operating voltage	0 to 1000	0 to 1000	0 to 1000	0 to 1000	0 to 1000	V	
Motion and positioning							
Closed-loop travel*	15	30	60	120	180	µm	
Closed-loop resolution*	0.3	0.6	1.2	2.4	3.6	nm	typ.
Open-loop resolution**	0.15	0.3	0.6	1.2	1.8	nm	typ.
Linearity error	0.2	0.2	0.2	0.2	0.2	%	typ.
Mechanical properties							
Static large-signal stiffness in the direction of motion***	860	600	380	210	150	N/µm	±20 %
Unloaded resonant frequency	14	10	7	4	2.8	kHz	±20 %
Push / pull force capacity in motion direction	30000 / 3500	30000 / 3500	30000 / 3500	30000 / 3500	30000 / 3500	N	max.
Shear load	707	420	232	147	147	N	max.
Torque on tip	2	2	2	2	2	Nm	max.
Drive properties							
Electrical capacitance	550	1100	2400	5100	7800	nF	±20 %
Dynamic operating current coefficient	65	65	65	65	65	µA / (Hz × µm)	±20 %
Other							
Mass (with cable)	580	690	940	1400	1900	g	±5 %

Piezo ceramic: PICA Power

Temperature range: -40 to 80 °C

The operating voltage should not exceed 750 V in continuous operation.

* Requires integrated strain gauge sensor. These versions are shipped with a performance report.

** Measured interferometrically. The position resolution of piezo actuators is not limited by stiction or friction.

*** Dynamic small-signal stiffness is approx. 50 % higher.

10.1.2 Maximum Ratings

P-2x5 piezo actuators are designed for the following operating data:

Piezo Actuator	Maximum operating voltage range	Maximum operating frequency without load		Maximum power consumption; considering thermal aspects***
		A: without considering thermal aspects*	B: considering thermal aspects**	
P-225.1x	0 V to 1000 V	4.7 kHz	29 Hz	50 W
P-225.2x	0 V to 1000 V	3.3 kHz	25 Hz	84 W
P-225.4x	0 V to 1000 V	2.3 kHz	22 Hz	152 W
P-225.8x	0 V to 1000 V	1.3 kHz	21 Hz	290 W
P-235.1x	0 V to 1000 V	4.7 kHz	23 Hz	68 W
P-235.2x	0 V to 1000 V	3.3 kHz	20 Hz	115 W
P-235.4x	0 V to 1000 V	2.3 kHz	16 Hz	208 W
P-235.8x	0 V to 1000 V	1.3 kHz	15 Hz	398 W
P-235.9x	0 V to 1000 V	0.93 kHz	14 Hz	585 W

* One third of the resonant frequency of the unloaded piezo actuator. For further restrictions, see "Overview of Limiting Factors" (p. 34).

** In order to prevent the maximum permissible operating temperature from being exceeded, the unloaded, **uncooled** piezo actuator may only be operated maximally with this operating frequency at an operating voltage of **1000 V peak-to-peak**. In the case of smaller amplitudes of the operating voltage and/or the use of cooling measures, higher operating frequencies are possible. For further restrictions, see "Overview of Limiting Factors" (p. 34).

*** Power consumption of the unloaded, uncooled piezo actuator that is operated at an operating voltage of **1000 V peak-to-peak** with the operating frequency from column B of this table.

10.1.3 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the P-2x5:

Area of application	For indoor use only
Maximum altitude	2000 m
Air pressure	1100 hPa to 0.1 hPa (corresponds to roughly 825 Torr to 0.075 Torr)
Relative humidity	Highest relative humidity 80% for temperatures up to 31 °C Decreasing linearly to 50% relative humidity at 40 °C
Operating temperature	–20 °C to 80 °C With models for high-temperature range and high vacuum (P-2x5.xxV/.xSV): –40 °C to 150 °C
Storage temperature	–20 °C to 80 °C
Transport temperature	–20 °C to 80 °C
Maximum bake-out temperature for vacuum-compatible products	Piezo actuators for high-temperature range and high vacuum (P-2x5.xxV/.xSV): 150 °C LEMO vacuum feedthroughs (see "Optional Accessories" (p. 15)): 100 °C
Overvoltage category	II
Protection class	I
Degree of pollution	1
Degree of protection according to IEC 60529	IP20

10.2 Dimensions

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

Standard tolerance according to DIN ISO 2768 - f - H

Roughness Ra 1.6

10.2.1 P-2x5 Piezo Actuator

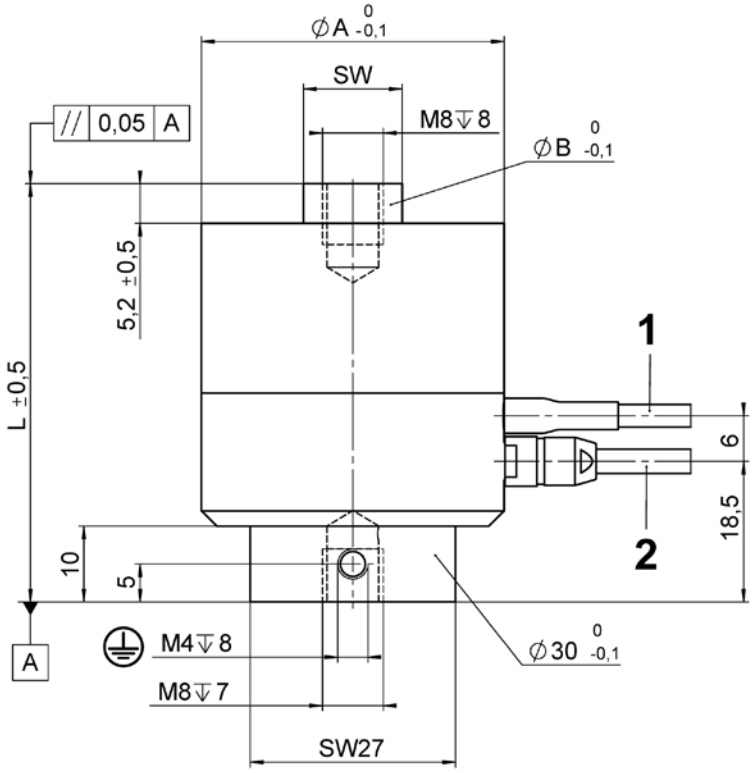


Figure 11: P-2x5

1: Sensor (only with models with position sensor and/or with P-177.50 option)
2: Piezo

	L [mm]	Ø A [mm]	Ø B [mm]	AF
P-225.1x	55	39.8	16	13
P-225.2x	68	39.8	16	13
P-225.4x	94	39.8	16	13
P-225.8x	147	39.8	16	13
P-235.1x	55	49.8	20	17
P-235.2x	68	49.8	20	17
P-235.4x	94	49.8	20	17
P-235.8x	147	49.8	20	17
P-235.9x	199	49.8	20	17

Not shown: When the P-2x5 has been ordered with the option "PT1000 temperature sensor and protective air connection for PICA HVPZT" (P-177.50) (p. 15), M3-PK-2 plug nipples are present for the protective air connection.

- Position of the protective air inlet: In the base of the piezo actuator across from the cable exit, 20 mm above the lower edge of the base
- Position of the protective air outlet: In the case tube of the piezo actuator above the cable exit, precise position upon request

➢ Contact our customer service department (p. 45) for details on the position of the plug nipples.

10.2.2 P-2x5 with the P-706.00 Option (Water-Resistant Case)

The dimensions of the P-2x5 with water-resistant case are supplied upon request.

➢ Contact our customer service department (p. 45).

10.2.3 Ball Tip P-176.B25

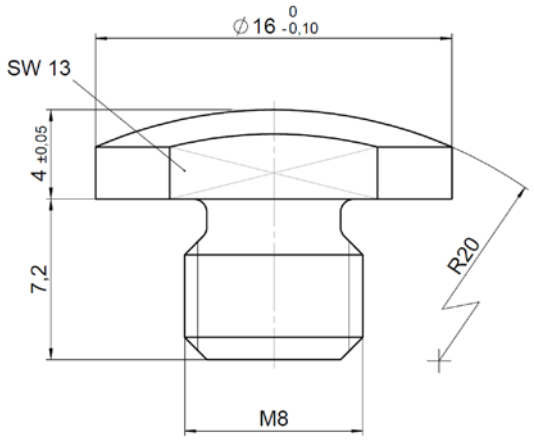


Figure 12: P-176.B25

10.2.4 Flat Tips P-176.F25 and P-176.F35

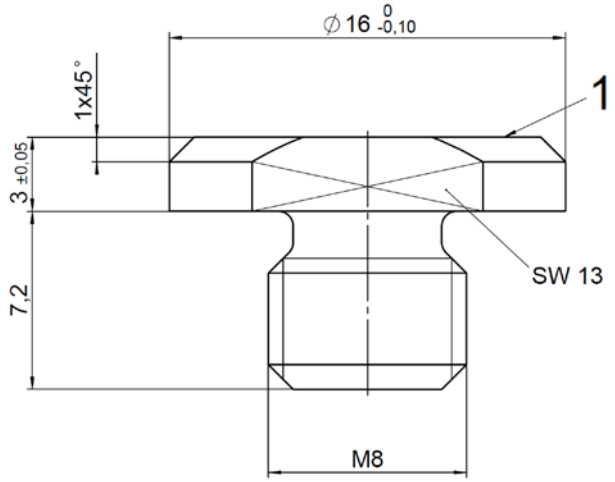


Figure 13: P-176.F25 (1 = Plane hardened and polished)

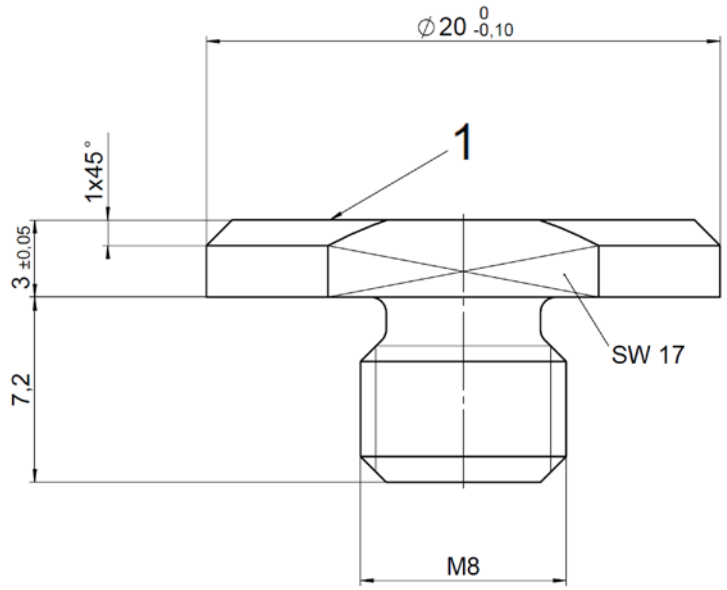


Figure 14: P-176.F35 (1 = Plane hardened and polished)

10.2.5 Vacuum Feedthrough for High-Voltage Piezo Actuators

LEMO SJG.0B.701.CJA.1173 (part of the P-203.VA option for high-voltage piezo actuators)

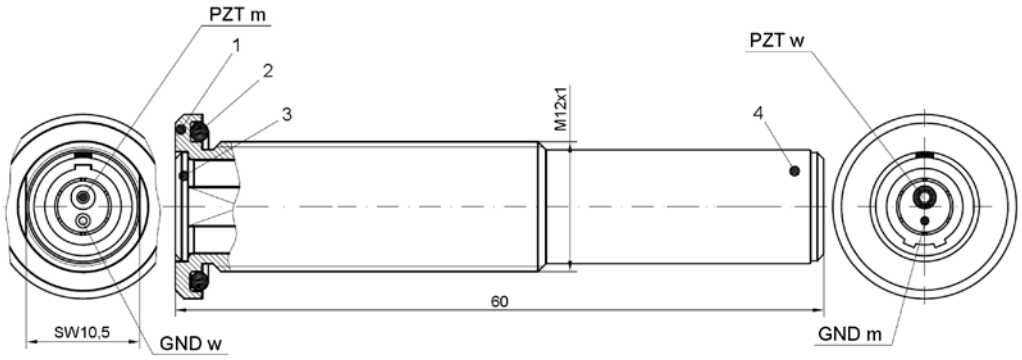


Figure 15: Vacuum feedthrough LEMO SJG.0B.701.CJA.1173

Designation	Description
1	Outer body
2	O-ring, Ø 12x1.5
3	LEMO device socket, "J" coded, EGJ.0B.701.CJA, flange side (atmosphere)
4	LEMO device socket, "G" coded, EGG.0B.701.CJL, vacuum side
PZT m	High-voltage contact, male, vacuum side
GND w	Female contact, GND, vacuum side
PZT w	High-voltage contact, female, flange side (atmosphere)
GND m	Male contact, GND, flange side (atmosphere)

10.2.6 Vacuum Feedthroughs for Sensors

The dimensions of the following vacuum feedthroughs are identical:

- LEMO SWH.0S.304.CLLSV (part of the P-892.VA option for SGS)
- LEMO SWH.0S.303.CLLSV (part of the P-899.VA option for temperature sensor)

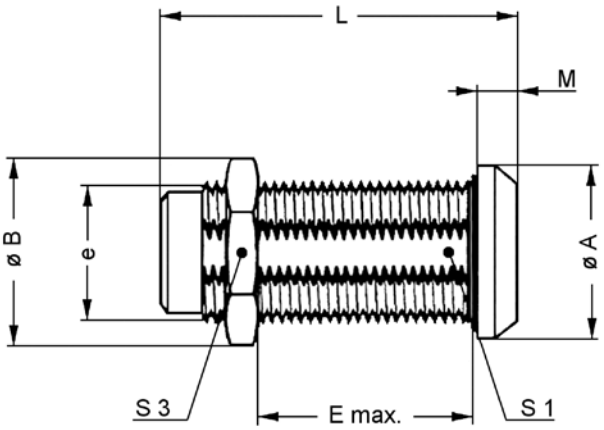


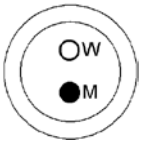
Figure 16: LEMO SWH.0S.30x.CLLSV

A	B	e	E	L	M	S1	S3
14 mm	13.8 mm	M10x0.75	17 mm	34 mm	2.0 mm	9.0 mm	12 mm

10.3 Pin Assignment

10.3.1 Voltage Connection

LEMO FGG.0B.701.CJA.1173

Connector (front view)	Pin	Signal	Function
	W (female)	Input	Piezo voltage 1000 V
	M (male)	GND	Ground

The connector shell is connected with the cable shield.

10.3.2 Connection of the Position Sensor

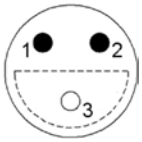
LEMO FFA.0S.304.CLA

Connector (front view)	Pin	Signal	Function
	1	Input	Supply voltage for strain gauge sensor
	2	Output	Sensor signal 1
	3	Output	Sensor signal 2
	4	GND	Ground

The connector shell is connected with the cable shield.

10.3.3 Connection of the Temperature Sensor

LEMO FFA.0S.303.CLA

Connector (front view)	Pin	Signal	Function
	1	Output	Temp_SA
	2	Output	Temp_S
	3	GND	Ground

The connector shell is connected with the cable shield.

11 Old Equipment Disposal

In accordance with the applicable EU law, electrical and electronic equipment may not be disposed of with unsorted municipal wastes in the member states of the EU.

When disposing of your old equipment, observe the international, national and local rules and regulations.

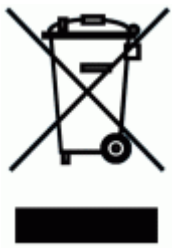
To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

If you have old PI equipment, you can send it postage-free to the following address:

Physik Instrumente (PI) GmbH & Co. KG

Auf der Römerstr. 1

D-76228 Karlsruhe, Germany



12 EC Declaration of Conformity

For the P-2x5, an EC Declaration of Conformity has been issued in accordance with the following European directives:

2006/95/EC, Low Voltage Directive

2004/108/EC, EMC Directive

2011/65/EU, RoHS Directive

The applied standards certifying the conformity are listed below.

Electromagnetic Emission: EN 61000-6-3:2007, EN 55011:2009

Electromagnetic Immunity: EN 61000-6-1:2007

Safety (Low Voltage Directive): EN 61010-1:2010